STRUCTURAL DETAILING STANDARDS

JUNE 2005

U.S. CUSTOMARY UNITS

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1 - General

A decision document (**Ref. 1**) and a transition plan (**Ref. 2**) were developed and approved to convert from Metric units to English units (U.S. Customary units).

U.S. Customary units (a.k.a. inch-pound or pound-inch units) are defined by the National Institute of Standards and Technology (NIST).

(*Web address:* http://ts.nist.gov/ts/htdocs/200/202/mpo_home.htm)

Users should become familiar with NIST and other equally reliable sources to obtain knowledge and skills exceeding the scope of this Structural Detailing Standards.

Items that need to adapt the U.S. Customary units should be sent to the chairperson of the Structure technical committee that addresses those specific items or to John Roccanova, the Department's Metric to U.S. Customary units Coordinator in the Office of Planning and Design.

Division of Engineering Services Office of Office Engineer (DES OOE) will convert the Standard Specifications, Standard Plans, Standard Special Provisions and the BEES (Basic Engineering Estimating System) to U.S. Customary units before the first U.S. Customary units project goes out for advertisement.

2 - Paper Sizes

U.S. Customary units drawings may be made on any size paper. The Division of Engineering Services will continue to use the 24" x 36" paper for structure plans. When sending the file to DES OOE, the files will be based on the 24" x 36" paper size.

3 - Drawing Sizes

The Division of Engineering Services will use the 24" x 36" paper with a 21" x 33 ½" ± drawing size for structure plans. Reduced set drawings will still be based on a 50% reduction.

4 - Scales

US Customary drawing scales are expressed in inches to feet ratios. Metric drawing scales are expressed in non-dimensional ratios.

Project Development is proposing the following for **Profile Sheets** (Reference 2)

A) Rural Sections in hilly or mountainous terrain
1"= 100' horizontal, 1" = 10'-0" vertical

B) Rural or urban with gentle rolling terrain
1"= 50' horizontal, 1" = 5'-0" vertical

C) Rural or urban with level terrain
1" = 20'-0" horizontal, 1" = 2'-0" vertical,

Project Development is proposing the following for **Cross Sections** (Reference 2)

A) Rural: 1" = 10'-0"

B) Urban: 1" = 5'-0"

The Office of Structure Design, Office of Structure Design Services & Earthquake Engineering, proposes the use of the following scales.

US Customary Scale	Close Metric Scale
1' = 1'-0" (Full Size)	1:1 (Full Size)
6" = 1'-0" (Half Size)	1:2 (Half Size)
3" = 1'-0"	1:4
1 1/2" = 1'-0"	1:8
1" = 1'-0"	1:10
3/4" = 1'-0"	1:20
1/2" = 1'-0"	1:25
3/8" = 1'-0"	1:30
1/4" = 1'-0"	1:50
3/16" = 1'-0"	1:80
1/8" = 1'-0"	1:100
3/32" = 1'-0"	1:125
1/16" = 1'-0"	1:200
1" = 10'	1:100
1" = 20'	1:250
1" = 30'	1:400
1" = 40'	1:500
1" = 50'	1:600
1" = 80'	1:1000
1" = 100'	1:1200
1" = 200'	1:2000
1" = 250'	1:3000
1" = 400'	1:5000
1" = 500'	1:6000
1" = 1000'	1:10000

5 - Units

Plans will contain U.S. Customary units only.

The preferred U.S. Customary units (base units) are the foot (') and inch (").

6 - Writing Conventions

For writing conventions for U.S. Customary units and numbers see “Metric Units to U.S. Customary Units General Primer [California Department of Transportation] - February 1, 2005”.

7 - U.S. Customary Units Conversions

Class	Multiply:	By:	To Get
Area	m^2	2.4710×10^{-4}	acre
	ha(10,000 m^2)	2.4710	acre
	m^2	10.7643	ft^2
	m^2	1.1960	yd^2
	km^2	0.3861	mi^2
Length *	m	3.2808	ft
	mm	0.0394	in
	µm	3.937×10^{-2}	mils
	km	0.6214	mi
	m	1.0936	yd

Class	Multiply:	By:	To Get
Volume	m^3	35.3357	ft^3
	L**	0.2642	gal
	ML**	0.0338	fl oz
	m^3	1.3079	yd^3
	m^3	8.1071×10^{-4}	acre ft
Mass	g	0.0353	oz
	kg	2.2046	lb
	tonne (1000kg)	2.2046	kip (1000 lb)
	kg	1.1023×10^{-3}	short ton (2000 lb)
	tonne (1000kg)	1.1023	short ton (2000 lb)
Force	N	0.2248	lb
	kN	0.2248	kip
	kN	0.1124	ton
Density	kg/m^3	1.6855	lb/yd^3
	kg/m^3	0.0624	lb/ft^3
Pressure	Pa	1.4504×10^{-4}	psi
	MPa (N/mm^2)	0.14504	ksi
	Pa	0.0209	psf
	kPa	20.8855	psf
	kPa	0.0209	ksf
Velocity	m/s	3.2808	ft/s
	m/s	2.2371	mi/h
	km/h	0.6214	mi/h
Light	lux (lx) ($lumen/m^2$)	0.0929	footcandle ($lumen/ft^2$)
Temperature	^oC	$t^oF = t^oC (9/5) + 32$	^oF

* The actual conversion factor is for the Survey Foot, where the factor is equal to $\frac{3937}{1200}$.

** "L" is used so as not to be confused with the numeral "1".

8 - Concrete Strength

Concrete f_c'	Use
25 MPa	3,600 psi
28 MPa	4,000 psi *
35 MPa	5,000 psi
42 MPa	6,000 psi

* Specify concrete strengths in 500 psi increments above 4000 psi.

Note: The standard design strength is 3600 psi.

9 - Reinforcement

U.S. Customary Units (Imperial) reinforcement will be used in place of metric reinforcement.

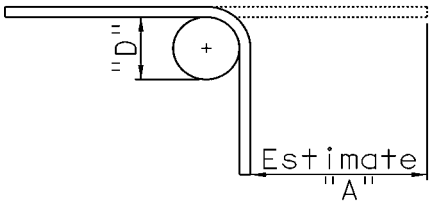
Imperial Reinforcing Bars: Use ASTM A706 Grade 60

Bar Sizes – Soft Metric* and Inch					
Bar Designation No.		Nominal Diameter		Nominal Area	
Metric*	Imperial	mm	in.	mm^2	$in.^2$
10	3	9.5	0.375	71	0.11
13	4	12.7	0.500	129	0.20
16	5	15.9	0.625	199	0.31
19	6	19.1	0.750	284	0.44
22	7	22.2	0.875	387	0.60
25	8	25.4	1.000	510	0.79
29	9	28.7	1.128	645	1.00
32	10	32.3	1.270	819	1.27
36	11	35.8	1.410	1006	1.56
43	14	43.0	1.693	1452	2.25
57	18	57.3	2.257	2581	4.00

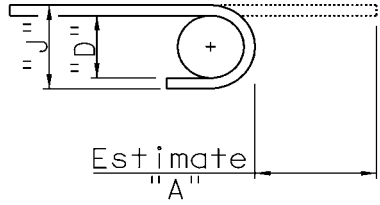
* Metric Bar Designation number approximates the number of millimeters of the nominal diameter of the bar.

Specify bar length to the nearest half inch for embedment and hook dimensions, and two inches for length.

Spacing of reinforcement should be shown to the nearest quarter inch. Spacing of reinforcement is assumed to be in inches unless otherwise noted. With this assumption, the inch symbol is not required.



90° Standard/
90° Stirrup Tie



180° Standard

Standard Hook Details
In accordance with ACI 318-02

Note: All dimensions are in inches

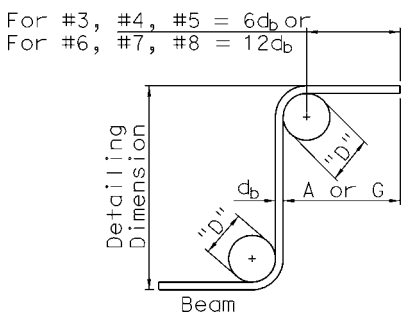
All grades:

D = finished inside bend diameter
d_b = nominal bar diameter

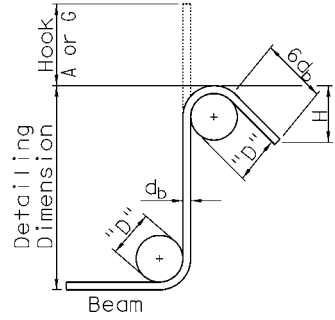
D = $6d_b$ for #3 through #8
D = $8d_b$ for #9, #10 and #11
D = $10d_b$ for #14 and #18

Recommended End Hooks, All Grades*				
Bar Size	D	180° Hooks		90° Hooks
		A	J	A
#3	2 ¼	5"	3 ¼"	6"
#4	3	6"	4 ¼"	8"
#5	3 ¾	7"	5 ¼"	10"
#6	4 ½	8"	6 ¼"	1'-0"
#7	5 ¼	10"	7 ¼"	1'-3"
#8	6	11"	8 ¼"	1'-5"
#9	9 ½	1'-3"	1'-0"	1'-7"
#10	10 ¾	1'-5"	1'-1 ½"	1'-10"
#11	12	1'-7"	1'-3"	2'-0"
#14	18 ¼	2'-3"	1'-10"	2'-7"
#18	24	3'-1"	2'-5"	3'-6"

· For information only



90°
Stirrup Hooks
(Tie Bends Similar)



135°
Stirrup Hooks
(Tie Bends Similar)

Stirrup/Tie Hook Details
In accordance with ACI 318-02

Note: All dimensions are in inches

All grades:

D = finished inside bend diameter

Stirrup Hooks (Tie Bends Similar)				
Bar Size	D	90° Hooks	135° Hooks	
		A or G	A or G	H
#3	1 ½"	4"	4"	2 ½"
#4	2"	4 ½"	4 ½"	3"
#5	2 ½"	6"	5 ½"	3 ¾"
#6	4 ½"	1'-0"	7 ¾"	4 ½"
#7	5 ¼"	1'-2"	9"	5 ¼"
#8	6"	1'-4"	10 ¼"	6"

D = finished inside bend diameter
"H" dimension is approximate
For Seismic hook, dimension length on detail.

Comparison of Deformed Bar Designation Numbers, Nominal Weights [Masses] and Nominal Dimensions				
Bar Designation Number [A]	Nominal Weight (lb/ft)	Nominal Dimensions [B]		
		Diameter (in.)	Cross-Sectional Area ($in.^2$)	Perimeter (in.)
3	0.376	0.375	0.11	1.178
4	0.668	0.500	0.20	1.571
5	1.043	0.625	0.31	1.963
6	1.502	0.750	0.44	2.356
7	2.044	0.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9	3.400	1.128	1.00	3.544
10	4.303	1.270	1.27	3.990
11	5.313	1.410	1.56	4.430
14	7.650	1.693	2.25	5.320
18	13.600	2.257	4.00	7.090

[A] Bar numbers are based on the number of eighth of an inch included in the nominal diameter of the bars.

[B] The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.

10 - Structural Steel

Structural Members sizes will conform to ASTM Specifications A6. In the future LFRD specifications will use non-dimensional property factors.

11 - Survey Information

(Reference 4)

All survey information will be expressed in feet.

Caltrans has adopted 100 feet per station. Stations will be to the nearest hundredth of a foot.

Elevations are to be expressed in feet, to the nearest hundredth of a foot.

For example:

- Elevation 324.35 (feet)
- Station 120+23.75
  120 (100 feet/station = 12,000 feet from source)
  23 (feet)
  0.75 (foot) = 9 inches

Angular measurement will retain degree-minute-second convention.

12 - Cross Slopes

(Reference 4)

Pavement cross slope and superelevation shall be shown as a percent.

13 - Side Slopes

(Reference 4)

Slope is expressed in non-dimensional ratios. The horizontal component is shown first and then the vertical component. Example: A three-foot run with an one-foot rise is expressed as 3:1. The units that are compared should be the same (foot to foot, inch to inch).

14 - Cross Section Intervals

(Reference 4)

Caltrans has adopted a 50-foot cross section interval. Cross section intervals may be reduced.

15 - Contour Intervals

(Reference 4)

HQ is proposing the following:

Scale	Index Contours	Intermediate Contours
1" = 20'	5'-0"	1'-0"
1" = 50'	10'-0"	2'-0"
1" = 100'	20'-0"	4'-0"
1" = 200'	50'-0"	10'-0"
1" = 400'	100'-0"	20'-0"

This seems adequate for our work, except as follows:

- Bridge deck contours use:
  Index contours = 1'-0"
  Intermediate contours = 0.2'

16 - Footings

Specify allowable pressures to the nearest 0.10 ksf.

Pressure	Soft	Proposed
145 kPa	3.031 ksf	3.00 ksf
190 kPa	3.971 ksf	4.00 ksf

17 - Piles

Specify pile diameter to the nearest 1 inch.
Example:

Pile Diameter	Soft	Proposed
300 mm	11.8"	12"
380 mm	15.0"	15"
400 mm	15.8"	16"

Specify pile spacing to the nearest 3 inches.
Example:

Pile Spacing	Soft	Proposed
500 mm	1-7 3/4"	1'-6"
900 mm	2-11 1/2"	3'-0"

Specify pile capacity to the nearest 10 kips.
Example:

Pile Capacity	Soft	Proposed
400 kN	89.92 kips	90 kips
625 kN	140.50 kips	140 kips
900 kN	202.32 kips	200 kips

Specify pile tip to the nearest 3 inches.
For example:

- Specified pile tip 24.25 (feet)

18 - Bolted Connection

(Structural Steel Joints)

ASTM Specification A325:

Standard Bolt and Hole– U.S. Customary Units Conversion					
AISC/LFRD (ASTM A325)				ISO/TC167 (ASTM A325M)	
Bolt Diameter	Hole	Bolt Diameter	Hole	Bolt Diameter	Hole
inches	inches	mm “soft”	mm “soft”	mm “hard”	mm “hard”
1/2	9/16	12.7	14.3	-	-
5/8	11/16	15.9	17.5	M16	18
3/4	13/16	19.0	20.6	M20	22
7/8	15/16	22.2	23.8	M22	24
1	1-1/16	25.4	27.0	M24	26
1 1/8	1-3/16	28.6	30.2	M27	30
1 1/4	1-5/16	31.8	33.3	M30	33
1 3/8	1-7/16	34.9	36.5	-	-
1 1/2	1-9/16	38.1	39.7	M36	39

19 - Bearing Pads and Joint Seal Assemblies

Steel reinforced bearing pads are vulcanized in a mold, so a soft conversion was used for the metric steel reinforced bearing pads (basically the U.S. Customary units dimensions were used). Returning to U.S. Customary units should be a direct or “soft” conversion.

The fabric pads will be dimensioned to the nearest two inches. Pad thickness should be determined in one half inch increments.

20 - Prestressed Concrete

Currently, 0.6" and 0.5" strands are used worldwide and will be retained as standards.

Prestressing Steel: 270 ksi, seven-wire, “Low Relaxation Strands” will be the standard.

P/S Notes: Round off P_{jack} to the nearest 100 kips and Anchor Set to the nearest sixteenth of an inch.

21 - Vertical Clearance

- 16.5' replaces 5.1 m
- 16.0' replaces 4.9 m
- 15.0' replaces 4.6 m
- 14.5' replaces 4.5 m

22 - EXAMPLES OF NOTES

A) Example of "General Notes"

GENERAL NOTES
LOAD FACTOR DESIGN

DESIGN:	CALTRANS BRIDGE DESIGN SPECIFICATIONS LFD Version April 2000 (1996 AASHTO with Interims and Revisions by Caltrans)
SEISMIC DESIGN:	CALTRANS SEISMIC DESIGN CRITERIA (SDC) Version 1.3, February 2004
DEAD LOAD:	Includes 35 psf for Future Wearing Surface Includes 10% of the additional deck dead load Between girders for Stay-in-Place deck forms for steel or precast girder structures
LIVE LOAD:	HS20-44 and Alternative and Permit Design Load
SEISMIC LOAD:	SDC ARS Curve for Soil Profiles ***X*** (M= 0.0 $\pm$ 0.0) Peak Rock Acceleration = 0.0g
REINFORCED CONCRETE:	f_y = 60,000 psi f'_c = 3600 psi (unless otherwise shown or specified) Transverse Deck Slabs (Working Stress): f_s = 20,000 psi f_c = 1200 psi n = 10
PRESTRESSED CONCRETE:	See "Prestressing Notes" on " " sheet
FOOTING PRESSURE:	See "Footing Data Table" on " " sheet
PILES:	See "Pile Data Table" on " " sheet

Example: Added DL for Stay-in-Place Deck Forms "July, 8 2000"
(See Memos to Designers 8-7 for application)

B) Example of "Prestressing Notes"

PRESTRESSING NOTES

270 ksi Low Relaxation Strands:

P_{jack} = _____ kips
Anchor Set = _____ inch
Friction curvature coefficient **μ** = _____ x 10^{-2} (1/rad)
Friction wobble coefficient **K** = _____ 0.0002 (1/ft)

Distribution of prestress force (Pjack) between girders shall not exceed the ratio of 3:2.

Maximum final force variation between girders shall not exceed 725 kips.

Concrete: f'_c = psi @ 28 days
f'_{ci} = psi @ time of stressing

Contractor shall submit elongation calculations based on initial stress at [**x**] =_____ times jacking stress.

One end stressing shall be performed from the long-span end only.

THIS CELL IS INTENDED FOR CIP/PS BOX GIRDERS STRUCTURES.

C) Example of "Pile Data Table"

PILE DATA TABLE – PIPE PILE						
Location	Pile Type	Design Load (kips)	Nominal Resistance (kips)		Design Tip Elevation (ft)	Specified Tip Elevation (ft)
			Compression	Tension		
Abut 1	PP 14"x1/2"	80	160	0	108.25	108.25
Bent 2	PP 14"x1/2"	N/A	268	0	95.25	95.25
Abut 3	PP 14"x1/2"	84	168	0	106.50	106.50

23 - REFERENCES

1) Decision Document “Review of Departmental Policy on Metrication – April 26, 2004 [Director’s Policy 15 and Deputy Directive 12]

2) Caltrans Metric to U.S. Customary Units Transition Plan – March 2005

3) Metric Units to U.S. Customary Units General Primer [California Department of Transportation] – February 1, 2005

4) Interim Drafting and CADD Guidelines – March 1, 2005